

# Leptophlebiidae Banks, 1900 (Insecta, Ephemeroptera) from Maranhão state, Brazil

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## Abstract

A checklist and new records of Leptophlebiidae (Ephemeroptera) are presented for the Maranhão state, in Brazil's Northeast Region. Fifteen 15 genera and 20 species of Leptophlebiidae were identified. *Farrodes xingu*, *Hermanellopsis arsia*, *Hydromastodon sallesi*, *Miroculis duckensis*, *Thraulodes marreroi*, and *Tikuna bilineata* are reported for the first time for the Northeast Region, and *Miroculitus emersoni* is recorded for the first time in Brazil. The number of known species of Leptophlebiidae in Maranhão is increased from three to 21.

## Keywords

Atalophlebiinae, biodiversity, Neotropical region, taxonomy, Terpidinae.

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## Introduction

Leptophlebiidae is one of the most diverse families of Ephemeroptera with about 270 species and 50 genera in the Neotropics (almost a third of the total number of genera and species) and with 75% endemism in this region (Salles et al. 2018). In Brazil, according to Salles and Boldrini (2020), 125 species and 28 genera are currently known.

Taxonomic knowledge of Ephemeroptera in Maranhão state it is still quite incipient, mainly due to the few projects developed and lack of researchers, although there are a few taxonomic studies from the east and south regions of Maranhão (Salles and Serrão 2005; Salles et al. 2007; Cruz et al. 2011; Lima et al. 2011; Boldrini et al. 2012; Salles and Domínguez 2012; Lima et al. 2016a).

Until now, the family Leptophlebiidae has been represented by only three species in the state: *Thraulodes sternimaculatus* Lima, Mariano & Pinheiro, 2013, *Traverella maranhensis* Nascimento, Lima & Azevêdo, 2019, and *Ulmeritoides uruguayensis* (Traver, 1959) (Salles and Domínguez 2012; Nascimento et al. 2019a).

Despite that Maranhão presents a rich network of watersheds and a great heterogeneity of aquatic environments, several areas from the east and south regions have undergone anthropogenic changes over the years, such as the conversion of large areas of native vegetation cover for agriculture and livestock (Feitosa and Almeida 2002; Araújo et al. 2011). The local ecosystems, and especially the areas of the Cerrado biome (a tropical



savanna ecoregion) where this research was carried out, have undergone major changes in their physiognomy. Deforestation of the riparian forest, fires, and discharge of solid and liquid waste in tributaries, are among the changes observed in several collection locations. Over the years, biodiversity has been lost, even before it is fully known (Barroso and Sousa 2007; Silva Junior et al. 2018).

The aim of our study was to survey the family Leptophlebiidae in Maranhão state and to provide new records and distributional notes, based on collections made in the basins of the Itapecuru, Parnaíba, and Tocantins rivers.

## Methods

Collections were made between February 2014 and October 2019 in six municipalities and at 18 localities

(Figs 1–8). The nymphs were captured using an aquatic net. When possible, nymphs were reared to obtain the adult stage. The imagos were captured on the banks of rivers using a light trap at dusk and a Pennsylvania trap from dusk to dawn (Frost 1957). Specimens were preserved in 80% ethanol.

Photographs were taken using a Zeiss Stereo Discovery Stereomicroscope V8 coupled to an AxioCam ICC 1 camera. AxioVision software was used to create multi-dimensional images with improved quality by processing a series of images at different focal positions. Wings were mounted dry. Male genital structures were examined in alcohol gel and permanently mounted on slides using Euparal® as the mounting medium, according to Edmunds et al. (1976). The genitalia were examined on a gel-containing plate, then fixed on permanent slides with Euparal.



**Figures 1–8.** 1. Map of South America highlighting the Maranhão state. 2. Map of Maranhão state indicating the collection sites. 3–8. Some of collection points 3. Farinha River, Cachoeira da Prata Waterfall, National Park of Chapada das Mesas, Carolina municipality. 4. Sítio creek, Mirador State Park, Mirador municipality. 5. Itapecuru River, Timbiras municipality. 6. Soledade creek, Inhamum Municipal Environmental Protection Area (APA Inhamum), Caxias municipality. 7. Poção creek, Aldeias Altas municipality. 8. São Félix creek, São João do Sóter municipality.



The identifications, diagnoses, and known distribution were based on Domínguez et al. (2006) and by careful comparisons to the original descriptions (e.g. Lima et al. 2013; Salles et al. 2016; Nascimento et al. 2017). The material examined is housed at the following locations: Coleção Zoológica do Maranhão (CZMA), Universidade Estadual do Maranhão, Caxias, Brazil; Laboratório de Entomologia Aquática (LEAq), Caxias, MA, Brazil.

## Results

The list of Leptophlebiidae found in this work are provided below. For each species we list geographical distribution data and provide a diagnosis. In the checklist (\*) means new records for Maranhão.

### Family Leptophlebiidae

#### *Askola emmerichi* Domínguez, Molineri & Mariano, 2009

Figures 9, 29

*Askola emmerichi* Domínguez et al. 2009: 31; Lima et al. 2016b: 216; Campos et al. 2019: 87.

**Diagnosis.** Male imago: 1) blackish marks on thorax and abdomen forming a pair of sublateral longitudinal lines (Fig. 9), wings with blackish marks; 2) dorsal portion of eyes grayish and widely meeting dorsally on meson of head (Fig. 9); 3) wings with blackish marks with four brown-spotted cross veins basal to bulla; 4) forceps yellowish brown, inner margins whitish (Fig. 29); 5) penis extending well beyond posterior margin of styliger plate (Fig. 29). (Adapted from Domínguez et al. 2009).

**Geographical distribution.** Brazil: states of Amazonas, Bahia, Maranhão\*, and Pernambuco. Colombia.

**Material examined.** BRAZIL • 3 imagos ♂; Maranhão state, Caxias municipality, Inhamum Municipal Environmental Protection Area, Riacho Soledade; 04°53'22.4"S, 043°25'27.5"W; 120 m a.s.l.; 04 Jun. 2014; S.R.S. Nascimento and G.R.D. Gomes leg; Pennsylvania trap; LEAq. • 1 imago ♂; Maranhão state, Caxias municipality, Inhamum Municipal Environmental Protection Area, Riacho Areia Branca; 04°53'34.9"S, 043°26'11.1"W; 118 m a.s.l.; 13 Mar. 2019; S.R.S. Nascimento leg; Pennsylvania trap; CZMA.

#### *Farrodes xingu* Domínguez, Molineri & Peters, 1996

Figures 10, 30

*Farrodes xingu* Domínguez et al. 1996: 97; Domínguez 1999: 175; Raimundi 2019: 39.

**Diagnosis.** Male imago: 1) projections of styliger plate long and narrow, with apex rounded (Fig. 30); 2) abdominal segments with extensive whitish marks (Fig. 10); 3) basal 1/3 penis lobes fused (Fig. 30); 4) apex of penis lobes rounded (Fig. 30); 5) lateral projections of penis cylindrical long, ending in a short flap (Fig. 30). Adapted from Domínguez et al. (1996).

**Geographical distribution.** Brazil: states of Goiás, Maranhão\* and Pará.

**Material examined.** BRAZIL • 19 imagos ♂; Maranhão state, Caxias municipality, Riacho Guarimã; 04°50'02.9"S, 043°29'06.1"W; 51 m a.s.l.; 16 Jun. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 1 imago ♂; Maranhão state, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 20 Dec. 2017; S.R.S. Nascimento, J.I.S. Jesus, D.C. Sousa and M.A.G. Almeida leg; light trap; LEAq. • 10 imagos ♂; same locality; 08 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; light trap; CZMA. • 7 ♂ imagos; same locality, 19 Nov. 2018; S.R.S. Nascimento and J.I.S. Jesus leg; light trap. • 1 subimago ♂ and 1 exuviae ♂; Maranhão state, São João do Sóter municipality, Riacho São Félix; 05°06'33.4"S, 043°35'56.7"W; 63 m a.s.l.; 07 Jun. 2019; S.R.S. Nascimento leg; Creation; CZMA.

#### *Fittkaulus cururuensis* Savage, 1986

Figure 11

*Fittkaulus cururuensis* Savage 1986: 268; Domínguez et al. 2002: 462; Boldrini et al. 2009: 220; Lima et al. 2012b: 309; Gama-Neto et al. 2018: 35

**Diagnosis.** Nymphs: 1) labrum with anteromedian emargination without denticles; 2) apex of galea-lacinia with one large, pectinate setae and one large, non-pectinate, curved setae; 3) coxae II and III with brown mark; 4) tergum yellow washed with brown, terga II–VII with sublateral yellow mark, terga VIII with median area yellow, posterior 2/3 of terga IX yellow. Female imago: 1) forewing without a dark macula at fork of vein MA; 2) coxae I and II, or II and III with brown mark; 3) abdominal sterna 1 and 2 with small posteromedian brownish black marks (Fig. 11). Adapted from Boldrini et al. (2009).

**Geographical distribution.** Brazil: states of Espírito Santo, Maranhão\*, Pará, Pernambuco, Piauí, and Roraima.

**Material examined.** BRAZIL • 1 imago ♀ and 1 exuviae ♀; Maranhão state, Caxias municipality, Riacho Planaçúcar; 04°54'24.8"S, 043°21'45.2"W; 71 m a.s.l.; 25 Oct. 2019; LEAq. • 3 imagos ♀ and 3 exuviae ♀; same locality, 26 Nov. 2019; S.R.S. Nascimento and J.I.S. Jesus leg; Creation; CZMA.

#### *Hermanellopsis arsia* Savage & Peters, 1983

Figures 12, 31

*Hermanellopsis arsia* Savage and Peters 1983: 574; Domínguez et al. 2006: 399; Raimundi et al. 2017: 581.

**Diagnosis.** Male subimago: 1) head brownish yellow, upper portion of compound eye brownish black (Fig. 12); 2) wing with posterior, well-developed costal projection; 3) portion posterior subgenital plate slightly straight, posterior margin with a tuft of thorns sclerosed later designed (Fig. 31); 4) straight penis tapering toward the apex (Fig. 31). Adapted from Savage and Peters (1983).





**Figures 9–18.** Dorsal habitus of some species of Leptophlebiidae (Ephemeroptera) found in Maranhão state, Brazil. **9.** *Askola emmerichi*. **10.** *Farrodes xingu*. **11.** *Fittkaulus cururuensis*. **12.** *Hermanellopsis arsia*. **13.** *Hydromastodon sallesi*. **14.** *Hydrosmilodon gilliesae*. **15.** *Leentvaaria palpalis*. **16.** *Miroculitus emersoni*. **17.** *Miroculis (Atroari) duckensis*. **18.** *Paramaka convexa*. Scale bars = 2 mm.



**Geographical distribution.** Brazil: states of Amazonas, Maranhão\*, and Roraima.

**Material examined.** BRAZIL • 16 subimagos ♂; Maranhão state, Caxias municipality, Inhamum Municipal Environmental Protection Area, Riacho Areia Branca; 04°53'34.9"S, 043°26'11.1"W; 118 m a.s.l.; 13 Aug. 2019; S.R.S. Nascimento leg; Pennsylvania trap; CZMA, LEAq.

***Hydromastodon sallesi* Polegatto & Batista, 2007**

Figures 13, 32

*Hydromastodon sallesi* Polegatto and Batista 2007: 53; Salles et al. 2016: 52.

**Diagnosis.** Male Imago: 1) eyes meeting on meson of head (Fig. 13); 2) cross vein above fork of MA slanted; 3) fork of MA asymmetrical and fork of MP slightly asymmetrical (MP2 connected to MP1 by a crossvein); 4) styliger plate with a strong dorsally curved median projection (Fig. 32); 5) penis divided, each lobe with a long spine ventromedially directed (Fig. 32) Adapted from Salles et al. (2016).

**Geographical distribution.** Brazil: states of Maranhão\*, Mato Grosso do Sul, Rondônia, and Roraima.

**Material examined.** BRAZIL • 7 imagos ♂; Maranhão state, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 20 Dec. 2017; S.R.S. Nascimento, J.I.S. Jesus, D.C. Sousa and M.A.G. Almeida leg; light trap; LEAq. • 10 imagos ♂; same locality, 08 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; light trap; LEAq. • 7 imagos ♂; 19 Nov. 2018. • 5 imagos ♂; 21 Nov. 2018; S.R.S. Nascimento and J.I.S. Jesus leg; light trap; LEAq. • 2 imagos ♂; Maranhão state, Timbiras municipality, Caixa D'água, Rio Itapecuru; 04°16'41.0"S, 043°57'16.3"W; 21 m a.s.l.; 13 Sep. 2018; S.R.S. Nascimento leg; light trap; CZMA.

***Hydrosmilodon gilliesae* Thomas & Péru, 2004**

Figures 14, 33

*Hydrosmilodon gilliesae* Thomas et al. 2004: 66; Domínguez et al. 2006: 405; Salles et al. 2010: 306; Lima et al. 2012a: 203; Lima et al. 2012b: 310; Salles et al. 2016: 47–51; Campos et al. 2017: 310.

**Diagnosis.** Male imago: 1) eyes separated on meson of head by a short distance less than 0.5 times width of median ocellus (Fig. 14); 2) forewings hyaline, slightly tinged with brown at base; 3) coloration of abdominal segments II–IX with blackish anterior and posterior stripes, and variable submedial marks (Fig. 14); 4) styliger plate with two wide projections that nearly cover the penis (Fig. 33); 5) penis lobes completely divided with distomedial spines converging medially (Fig. 33). Adapted from Salles et al. (2016).

**Geographical distribution.** Brazil: states of Bahia, Espírito Santo, Maranhão\*, Mato Grosso, Pernambuco, Roraima, and São Paulo. French Guyana.

**Material examined.** BRAZIL • 2 imagos ♂; Maranhão State, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 19 Dec. 2017.

• 1 imago ♂; same locality, 20 Dec. 2017; S.R.S. Nascimento, J.I.S. Jesus, D.C. Sousa and M.A.G. Almeida leg; light trap; LEAq. • 2 imagos ♂; Maranhão state, Timbiras municipality, Caixa D'água, Rio Itapecuru; 04°16'41.0"S, 043°57'16.3"W; 21 m a.s.l.; 13 Sep. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 7 imagos ♂; Maranhão state, Caxias municipality, Buriti do Meio Municipal Environmental Protection Area, Riacho Jatobá, 04°54'34.4"S, 043°07'00.7"W; 81 m a.s.l.; 17 Mar. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 37 imagos ♂; Maranhão state, Carolina municipality, National Park Chapada das Mesas, Farinha River, Cachoeira da Prata Waterfall; 06°59'37.8"S, 047°09'58.1"W; 201 m a.s.l.; 17 May 2018; L.R.C. Lima and S.R.S. Nascimento leg; light trap; LEAq. • 106 imagos ♂; Maranhão state, Codó municipality, Rio Saco, BR316; 04°37'29.4"S, 043°54'09.1"W; 63 m a.s.l.; 22 Oct. 2019; S.R.S. Nascimento, L.R.C. Lima and J.I.S. Jesus leg; light trap; CZMA.

***Leentvaaria palpalis* Demoulin, 1966**

Figures 15, 34

*Leentvaaria palpalis* Demoulin 1966: 14; Hubbard 1982: 265; Domínguez et al. 2001: 314; Domínguez et al. 2006: 411; Lima et al. 2012a: 203; Lima et al. 2012b: 311; Salles et al. 2016: 56–59.

**Diagnosis.** Male imago: 1) eyes meeting on meson of head (Fig. 15); 2) fork of MA asymmetrical and fork of MP slightly asymmetrical; 3) crossvein above fork of MA not slanted; 4) styliger plate enlarged posteriorly, completely covering penis lobes in ventral view (Fig. 34); 5) penis divided, each lobe with a long spine apically curved (Fig. 34). Adapted from Salles et al. (2016).

**Geographical distribution.** Brazil: states of Espírito Santo, Maranhão\*, Mato Grosso, Pernambuco, and Roraima. Suriname and Venezuela.

**Material examined.** BRAZIL • 1 imago ♂; Maranhão state, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 60 m a.s.l.; 19 Dec. 2017. • 3 imagos ♂; same locality, 20 Dec. 2017; S.R.S. Nascimento, J.I.S. Jesus, D.C. Sousa and M.A.G. Almeida leg; light trap; LEAq. • 23 imagos ♂; 08 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima; M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; light trap; LEAq. • 20 imagos ♂; 19 Nov. 2018; • 44 imagos ♂; 20 Nov. 2018; S.R.S. Nascimento, J.I.S. Jesus leg; light trap; LEAq. • 1 imago ♂; Maranhão state, Caxias municipality, Mangueira, Rio Itapecuru; 05°07'05.5"S, 043°33'47.8"W; 69 m a.s.l.; 09 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; light trap; LEAq. • 2 imagos ♂; Maranhão state, Caxias municipality, Riacho Guarimã; 04°50'02.9"S, 043°29'06.1"W; 51 m a.s.l.; 16 Jun. 2018; S.R.S. Nascimento leg; light trap; CZMA.

**Remarks.** Salles et al. (2016) described the male imago with eyes separated on the meson of head by a short distance (less than 0.5 times the width of the median



ocellus). However, we found specimens with the eyes not separated, meeting on meson of the head (Fig. 15).

***Miroculitus emersoni* (Needham & Murphy, 1924)**

Figures 16, 35

*Choroterpes emersoni* Needham and Murphy 1924: 47; Traver 1947: 154.

*Choroterpes (Choroterpes) emersoni*—Hubbard 1982: 264.

*Miroculitus emersoni*—Savage and Peters 1983: 568.

**Diagnosis.** Male imago: 1) membrane of forewings hyaline; 2) middle and hind femora yellowish brown, with submedian and apical blackish-brown maculae; and 3) penis dark brown, tubular with rows of basal spines (Fig. 35). Adapted from Needham and Murphy (1924).

**Geographical distribution.** Brazil: Maranhão\*. Guyana.

**Material examined.** BRAZIL • 1 imago ♂; Maranhão state, Caxias municipality/Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 19 Dec. 2017; S.R.S. Nascimento, J.I.S. Jesus, D.C. Sousa and M.A.G. Almeida leg; light trap; LEAq. • 1 subimago ♂; Maranhão state, Caxias municipality, Mangueira, Rio Itapecuru, 05°07'05.5"S, 043°33'47.8"W; 69 m a.s.l.; 09 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; Pennsylvania trap; CZMA.

***Miroculis (Atroari) duckensis* Savage & Peters, 1983**

Figures 17, 36

*Miroculis (Atroari) duckensis* Savage and Peters 1983: 554; Domínguez et al. 2002: 463; Salles et al. 2004: 25; Lopes et al. 2007: 142.

**Diagnosis.** Male imago: 1) forewing with light-brown, irregular, transverse submedian band and numerous maculae of same color; 2) penis between 1.1 and 1.4 times length of segment I of forceps, each penis lobe tapered apically (Fig. 36); 3) color pattern of abdominal terga IV–VII as in Figure 17. Adapted from Savage and Peters (1983).

**Geographical distribution.** Brazil: states of Amazonas and Maranhão\*.

**Material examined.** BRAZIL • 29 imagos ♂; Maranhão state, Caxias municipality, Inhamum Municipal Environmental Protection Area, Riacho Areia Branca; 04°53'34.9"S, 043°26'11.1"W; 118 m a.s.l.; 04 Oct. 2019; S.R.S. Nascimento leg; Creation; CZMA, LEAq.

***Paramaka convexa* (Spieth, 1943)**

Figures 18, 37

*Thraululus convexus* Spieth 1943: 10.

*Homothraululus convexus*—Traver 1960: 73; Hubbard 1982: 265.

*Hermanella* sp. 2.—Demoulin 1966: 12.

*Paramaka convexa*—Savage and Domínguez 1992: 244; Blanco-Belmonte et al. 2003: 119.

**Diagnosis.** Male imago: 1) membrane of fore and hind wings hyaline with faint yellow tinge, longitudinal and cross veins of forewings brown and distinct; 2) abdominal segments II–VI translucent yellow, I and VII–X dark (Fig. 18); 3) genitalia with ventral spine-like projections

directed anteromesally (Fig. 37). Adapted from Spieth (1943).

**Geographical distribution.** Brazil: states of Pará and Maranhão\*. Colombia, French Guyana, Suriname, and Venezuela.

**Material examined.** BRAZIL • 5 imagos ♂; Maranhão state, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 01 Feb. 2014; S.R.S. Nascimento, D.C. Sousa and G.R.D. Gomes leg; light trap; LEAq. • 11 imagos ♂; same locality, 19 Dec. 2017. • 8 imagos ♂; 20 Dec. 2017; S.R.S. Nascimento, J.I.S. Jesus, D.C. Sousa and M.A.G. Almeida leg; light trap; LEAq. • 5 imagos ♂; 08 Mar. 2018. • 3 imagos ♂; 09 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; light trap; LEAq. • 1 imago ♂; 19 Nov. 2018. • 7 imagos ♂; 2 Nov. 2018; S.R.S. Nascimento and J.I.S. Jesus leg; light trap; LEAq. • 3 imagos ♂; Maranhão state, Caxias municipality, Riacho Guarimã; 04°50'02.9"S, 043°29'06.1"W; 51 m a.s.l.; 16 Jun. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 95 imagos ♂; Maranhão state, Carolina municipality, National Park Chapada das Mesas, Farinha River, Cachoeira da Prata Waterfall; 06°59'37.8"S, 047°09'58.1"W; 201 m a.s.l.; 17 May 2018; L.R.C. Lima and S.R.S. Nascimento leg; light trap; LEAq. • 3 imagos ♂; Maranhão state, Codó municipality, Boca da Mata, Rio Itapecuru; 04°28'27.5"S, 043°47'20.5"W; 38 m a.s.l.; 12 Sep. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 2 imagos ♂; Maranhão state, Timbiras municipality, Caixa D'água, Rio Itapecuru; 04°16'41.0"S, 043°57'16.3"W; 21 m a.s.l.; 13 Sep. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 5 imagos ♂; Maranhão state, Codó municipality, Rio Saco, BR316; 04°37'29.4"S, 043°54'09.1"W; 63 m a.s.l.; 22 Oct. 2019; S.R.S. Nascimento, L.R.C. Lima and J.I.S. Jesus leg; light trap; CZMA.

***Simothraulopsis demerara* Traver, 1947**

Figures 19, 38

*Thraululus demerara* Traver 1947: 150; Traver 1960: 73.

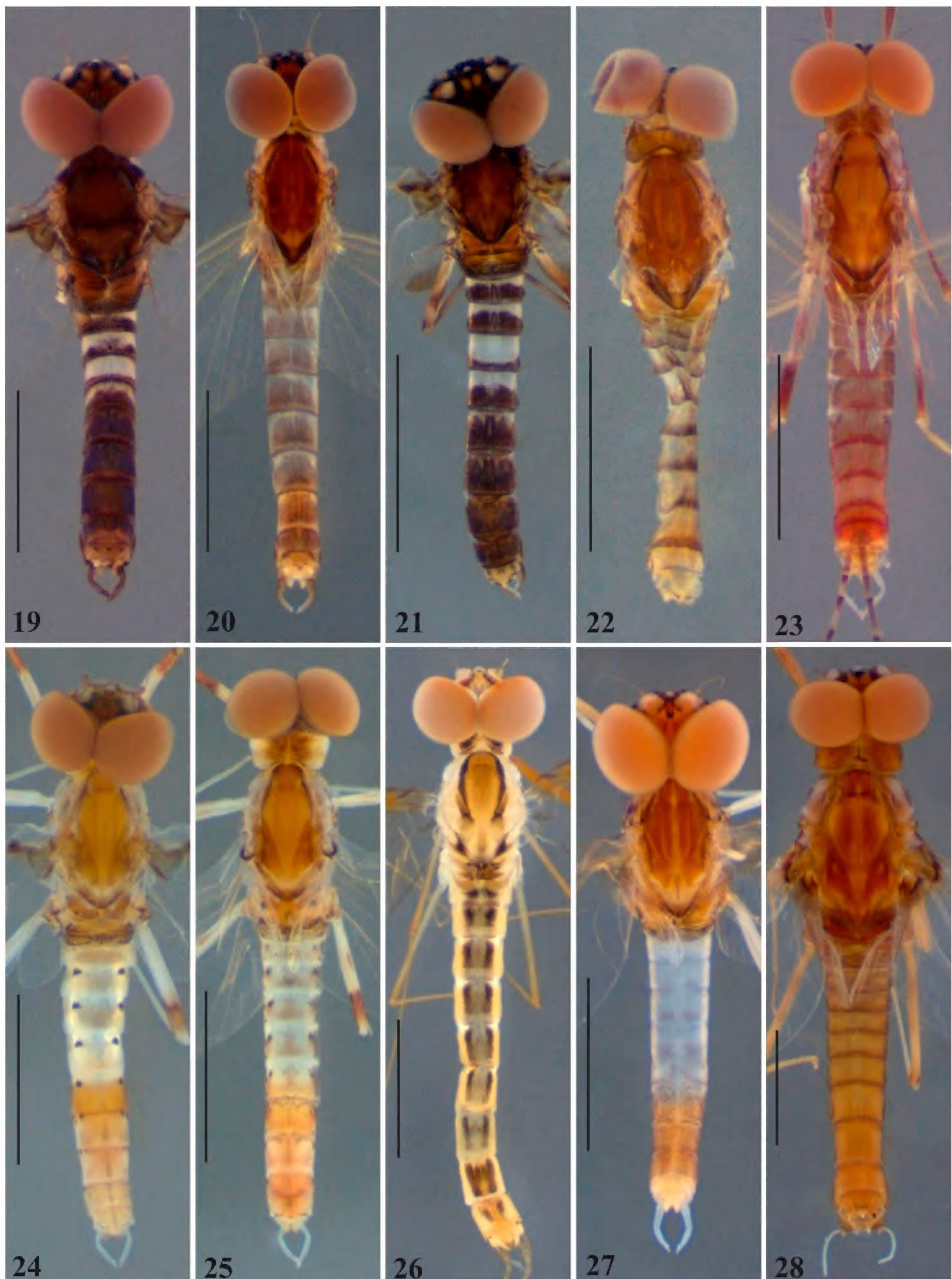
*Simothraulopsis surinamensis* Demoulin 1966: 18; Hubbard 1982: 266.

*Simothraulopsis demerara*—Domínguez et al. 1997: 146 (synonym of *S. surinamensis*).

*Simothraulopsis demerara*—Kluge 2007: 388; Salles et al. 2010: 306; Gama-Neto and Hamada 2014: 285; Nascimento et al. 2017: 9; Faria and Salles 2019: 376; Raimundi 2019: 40.

**Diagnosis.** Male imago: 1) general coloration: thorax orangish brown, abdomen grayish brown (Fig. 19); 2) forewing with two costal cross veins basal to bulla; 3) hind wing with costal projection well developed, forming an acute angle, located approximately 2/3 distance from base to apex of wing; 4) abdominal segments II–V with translucent white basal bands (Fig. 19); 5) penis projection spine-like, long and anteriorly directed (Fig. 38); 6) penis lobes fused on basal 1/3 (Fig. 38); 7) ventral region of penis lobes without a well-marked sclerotized region (Fig. 38). Adapted from Traver (1947).





**Figures 19–28.** Dorsal habitus of some species of Leptophlebiidae (Ephemeroptera) found in Maranhão state, Brazil. **19.** *Simothraulopsis demerara*. **20.** *S. diamantinensis*. **21.** *S. janae*. **22.** *S. sinuosus*. **23.** *Thraulodes luizgonzagai*. **24.** *T. marreroi*. **25.** *T. sternimaculatus*. **26.** *Tikuna bilineata*. **27.** *Traverella maranhensis*. **28.** *Ulmeritoides flavopedes*. Scale bars = 2 mm.



**Geographical distribution.** Brazil: states of Acre, Amapá, Amazonas, Bahia, Ceará, Espírito Santo, Goiás, Maranhão\*, Mato Grosso, Pará, Paraná, Pernambuco, Piauí, Rondônia, Roraima, and Tocantins. French Guyana, Guyana, Suriname, and Venezuela.

**Material examined.** BRAZIL • 7 imagos ♂; Maranhão state, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 01 Feb. 2014; S.R.S. Nascimento, D.C. Sousa and G.R.D. Gomes leg; light trap; LEAq. • 6 imagos ♂; same locality, 19 Dec. 2017. • 1 imago ♂; 20 Dec. 2017; S.R.S. Nascimento, J.I.S. Jesus, D.C. Sousa and M.A.G. Almeida leg; light trap; LEAq. • 9 imagos ♂; 08 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; light trap; LEAq. • 5 imagos ♂; 19 Nov. 2018. • 9 imagos ♂; 21 Nov. 2018; S.R.S. Nascimento and J.I.S. Jesus leg; light trap; LEAq. • 3 imagos ♂; Maranhão state, Caxias municipality, Mangueira, Rio Itapecuru; 05°07'05.5"S, 043°33'47.8"W; 69 m a.s.l.; 09 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; light trap; LEAq. • 13 imagos ♂; Maranhão state, Caxias municipality, Riacho Guarimã; 04°50'02.9"S, 043°29'06.1"W; 51 m a.s.l.; 16 Jun. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 18 imagos ♂; Maranhão state, Caxias municipality, Buriti do Meio Municipal Environmental Protection Area, Riacho Jatobá; 04°54'34.4"S, 043°07'00.7"W; 81 m a.s.l.; S.R.S. Nascimento leg; light trap; LEAq. • 3 imagos ♂; Maranhão state, Carolina municipality, National Park Chapada das Mesas, Farinha River, Cachoeira da Prata Waterfall; 06°59'37.8"S, 047°09'58.1"W; 201 m a.s.l.; 17 May. 2018; L.R.C. Lima and S.R.S. Nascimento leg; light trap; LEAq. • 3 imagos ♂; Maranhão state, Codó municipality, Rio Saco; 04°31'57.3"S, 043°54'48.4"W; 62 m a.s.l.; 11 Sep. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 1 imago ♂; Maranhão state, Timbiras municipality, Caixa D'água, Rio Itapecuru; 04°16'41.0"S, 043°57'16.3"W; 21 m a.s.l.; 13 Sep. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 1 subimago ♂; 1 exuviae ♂; Maranhão state, Aldeias Altas municipality, Riacho Poção; 04°40'20.5"S, 043°32'21.4"W; 52 m a.s.l.; 04 Oct. 2018; S.R.S. Nascimento leg; Creation; LEAq. • 11 imagos ♂; Maranhão state, Codó municipality, Rio Saco, BR316; 04°37'29.4"S, 043°54'09.1"W; 63 m a.s.l.; 22 Oct. 2019; S.R.S. Nascimento, L.R.C. Lima and J.I.S. Jesus leg; light trap; CZMA.

***Simothraulopsis diamantinensis* Mariano, 2010**

Figures 20, 39

*Simothraulopsis diamantinensis* Mariano 2010: 130; Nascimento et al. 2017: 30; Boldrini and Krolow 2017: 3; Faria and Salles 2019: 376.

**Diagnosis.** Male imago: 1) general coloration: thorax dark brown, abdomen orangish brown (Fig. 20); 2) hind wing with costal projection almost forming a right angle, located approximately ½ distance from base to apex of wing, without a cross vein; 3) terga III–V with anterior region translucent white (Fig. 20); 4) penis projection

spine-like, short (less than half of total length of penis lobes) and directed to the midline of the body (Fig. 39); 5) penis lobes fused on basal ¼ (Fig. 39); 6) ventral region of penis lobes without a well-marked sclerotized region (Fig. 39). Adapted from Mariano (2010).

**Geographical distribution.** Brazil: states of Bahia, Maranhão\*, Paraná, and Tocantins.

**Material examined.** BRAZIL • 3 imagos ♂; Maranhão state, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 08 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; light trap; LEAq. • 2 imagos ♂; Maranhão state, Caxias municipality, Mangueira, Rio Itapecuru; 05°07'05.5"S, 043°33'47.8"W; 69 m a.s.l.; 09 Mar. 2018; S.R.S. Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; light trap; CZMA.

***Simothraulopsis janae* Mariano, 2010**

Figures 21, 40

*Simothraulopsis janae* Mariano 2010: 132; Lima et al. 2012b: 311; Gama-Neto and Hamada 2014: 285; Nascimento et al. 2017: 37.

**Diagnosis.** Male imago: 1) hind wing with costal projection forming an acute angle, located approximately ⅔ distance from base to apex of wing; 2) abdominal segments II–VI with translucent white basal bands (Fig. 21); 3) penis lobes with sclerotized thin plate on dorsal region (Fig. 40); 4) penis lobes slender, fused on basal ⅔ (Fig. 40); 5) penis projection spine-like, of moderate size (approximately ½ of the total length of penis lobes) and laterally directed (Fig. 40); 6) ventral region of penis lobes without a well-marked sclerotized region (Fig. 40). Adapted from Mariano (2010).

**Geographical distribution.** Brazil: states of Bahia, Mato Grosso, Maranhão\*, Minas Gerais, Pará, Pernambuco, Rondônia, and Roraima.

**Material examined.** BRAZIL • 15 imagos ♂; Maranhão state, Caxias municipality, Riacho Guarimã; 04°50'02.9"S, 043°29'06.1"W; 51 m a.s.l.; 16 Jun. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 3 imagos ♂; Maranhão state, Codó municipality, Rio Saco; 04°31'57.3"S, 043°54'48.4"W; 62 m a.s.l.; 11 Sep. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 5 imagos ♂; Maranhão state, Timbiras municipality, Caixa D'água, Rio Itapecuru; 04°16'41.0"S, 043°57'16.3"W; 21 m a.s.l.; 13 Sep. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 12 imagos ♂; Maranhão state, Codó municipality, Rio Saco, BR316; 04°37'29.4"S, 043°54'09.1"W; 63 m a.s.l.; 22 Oct. 2019; S.R.S. Nascimento, L.R.C. Lima and J.I.S. Jesus leg; light trap; CZMA.

***Simothraulopsis sinuosus* Lima, 2018**

Figures 22, 41

*Simothraulopsis sinuosus* Lima 2018: 254.

**Diagnosis.** Male imago: 1) hind wing with costal projection forming a right angle, located approximately ½ distance from base to apex of wing; 2) abdominal terga



II–VII with medio-basal, translucent, yellow angles (Fig. 22); 3) penis projection spine-like, sinuous, medium-sized (approximately  $\frac{1}{2}$  of the total length of penis lobes), slightly laterally directed (Fig. 41); 4) penis lobes fused on basal half, with a shallow concavity in the junction of the lobes (Fig. 41). Adapted from Lima (2018).

**Geographical distribution.** Brazil: states of Maranhão\* and Piauí.

**Material examined.** BRAZIL • 1 imago ♂; Maranhão state, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 20 Dec. 2017; S.R.S. Nascimento, J.I.S. Jesus, D.C. Sousa and M.A.G. Almeida leg; light trap; LEAq.

***Thraulodes luizgonzagai* Lima, Mariano & Pinheiro, 2013**

Figures 23, 42

*Thraulodes luizgonzagai* Lima et al. 2013: 232.

**Diagnosis.** Male imago: 1) costal membrane basal to bulla without cross veins; 2) costal and subcostal zones of forewing translucent; 3) two dark-brown bands on femora; 4) terga in dorsal view predominantly light brown, in lateral view translucent whitish, with three distinct spots on terga II–VI and one spot on terga VII–VIII (Fig. 23); 5) subapical spines of penis long and narrow, apicolateral area not forming an “ear”, lateral pouch present, and without recurved folds (Fig. 42). Adapted from Lims et al. (2013).

**Geographical distribution.** Brazil: states of Maranhão\* and Pernambuco.

**Material examined.** BRAZIL • 3 imagos ♂; Maranhão state, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 2019 Nov. 2018; S.R.S. Nascimento and J.I.S. Jesus leg; light trap; CZMA, LEAq.

***Thraulodes marrerai* Chacón, Segnini & Domínguez, 1999**

Figures 24, 43

*Thraulodes marrerai* Chacón et al. 1999: 255; Gama-Neto et al. 2018: 38; Kluge 2020: 61.

**Diagnosis.** Male imago. 1) forewings without crossveins basal to bulla; 2) main longitudinal veins yellowish; 3) abdominal color pattern with central area of terga II–IV tinged with reddish (Fig. 24); 4) femora I with apical  $\frac{1}{5}$  covered with a tricolored spot; 5) penis long and stout, spine long and narrow; apicolateral area forming a pronounced “ear”; external margin forming a small lateral pouch; recurved fold slightly angulated (Fig. 43). Adapted from Chacón et al. (1999).

**Geographical distribution.** Brazil: Maranhão\* and Roraima. Panama and Venezuela.

**Material examined.** BRAZIL • 12 imagos ♂; Maranhão state, Codó municipality, Rio Saco, BR316; 04°37'29.4"S, 043°54'09.1"W; 63 m a.s.l.; 22 Oct. 2019; S.R.S.

Nascimento, L.R.C. Lima and J.I.S. Jesus leg; light trap; CZMA, LEAq.

***Thraulodes sternimaculatus* Lima, Mariano & Pinheiro, 2013**

Figures 25, 44

*Thraulodes sternimaculatus* Lima et al. 2013: 236; Boldrini et al. 2018: 280; Nascimento et al. 2019a: 287.

**Diagnosis.** Male imago: 1) costal membrane basal to bulla without cross veins; 2) costal and subcostal zones of the forewing translucent; 3) one band on femora; 4) abdominal segments in dorsal view predominantly translucent, with three dark, lateral spots on terga II–VII (Fig. 25); 5) subapical spines of penis short and narrow, apicolateral area not forming an “ear”, lateral pouch present and without recurved folds (Fig. 44). Adapted from Lima et al. (2013).

**Geographical distribution.** Brazil: states of Maranhão, Pernambuco, and Piauí.

**Material examined.** BRAZIL • 93 imagos ♂; Maranhão state, Caxias municipality, Riacho Guarimã; 04°50'02.9"S, 043°29'06.1"W; 51 m a.s.l.; 16 Jun. 2018; S.R.S. Nascimento leg; light trap; CZMA, LEAq.

***Tikuna bilineata* (Needham & Murphy, 1924)**

Figures 26, 45

*Choroterpes bilineata* Needham and Murphy 1924: 48.

*Tikuna bilineata* Peters et al. 2005: 52; Domínguez et al. 2006: 511; Boldrini et al. 2009: 7; Angeli et al. 2015: 202; Boldrini and Krolow 2017: 3; Raimundi 2019: 40.

**Diagnosis.** Male imago: 1) membrane of forewings with costal strip of yellowish to light-tan pigment; 2) terga segments I–VII with longitudinal submedial black mark (Fig. 26); 3) penis short; basal  $\frac{1}{2}$  fused, mid-lateral margins with projections, apices without appendages (Fig. 45). Adapted from Needham and Murphy (1924).

**Geographical distribution.** Brazil: states of Amazonas, Espírito Santo, Goiás, Maranhão\*, Mato Grosso, Pará, and Tocantins. Colombia, Ecuador, Peru, Suriname, and Venezuela.

**Material examined.** BRAZIL • 3 subimago ♂; Maranhão state, Caxias municipality, Mangueira, Rio Itapecuru; 05°07'05.5"S, 043°33'47.8"W; 69 m a.s.l.; 09 Mar. 2018; Nascimento, L.R.C. Lima, M.A.G. Almeida, J.A.O. Rodrigues and D.A. Barbosa leg; Pennsylvania trap; LEAq. • 1 imago ♂; Maranhão state, Caxias municipality, Pé da Serra, Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 06 Dec. 2019; S.R.S. Nascimento and J.I.S. Jesus leg; light trap; CZMA.

***Traverella maranhensis* Nascimento, Lima & Azevêdo, 2019**

Figures 27, 46

*Traverella maranhensis* Nascimento et al. 2019: 196.

**Diagnosis.** Male Imago: 1) vein ICu1 of forewings free basally; 2) subgenital plate forming two broad, lateral projections with two narrow, long, dorsally recurved



spines (Fig. 46); 3) penis lobe divided on distal  $\frac{3}{4}$  (Fig. 46); 4) penis lobe triangular and apically rounded, with a long, ventral spine both slightly curved and directed to midline (Fig. 46). Adapted from Nascimento et al. (2019b).

**Geographical distribution.** Brazil: Maranhão state.

**Material examined.** BRAZIL • 10 imagos ♂; Maranhão state, Pé da Serra/Rio Itapecuru; 05°07'28.5"S, 043°33'02.3"W; 68 m a.s.l.; 08 Mar. 2018; S.R.S. Nascimento, D.C. Sousa and J.I.S. Jesus leg; light trap; CZMA, LEAq.

### *Ulmeritoides flavopedes* Spieth, 1943

Figures 28, 47

*Thraululus flavopedes* Spieth 1943: 11.

*Atalophlebioides flavopedes*—Traver 1946: 426.

*Ulmeritoides oepa* Lopes et al. 2003: 195; Domínguez et al. 2006: 527; Salles and Domínguez 2012: 59.

*Ulmeritoides flavopedes*—Domínguez 1991: 162; Domínguez et al. 2006: 524; Salles and Domínguez 2012: 59; Lima et al. 2015: 5; Lima et al. 2016b: 217; Boldrini and Krolow 2017: 3.

**Diagnosis.** Male imago: 1) membrane of forewings hyaline, wing bases brown; 2) abdominal terga orange-brown, posterior margins blackish (Fig. 28); 3) apex of penis lobes rounded, each with a lateral groove (Fig. 47). Adapted from Spieth (1943).

**Geographical distribution.** Brazil: states of Bahia, Maranhão\*, Mato Grosso, Pernambuco, and Roraima.

**Material examined.** BRAZIL • 20 imagos ♂; Maranhão state, Caxias municipality, Buriti do Meio Municipal Environmental Protection Area, Riacho Jatobá; 04°54'34.4"S, 043°07'00.7"W; 81 m a.s.l.; 17 Mar. 2018; S.R.S. Nascimento leg; light trap; CZMA. • 5 imagos ♂; Maranhão state, Codó municipality, Rio Saco; 04°31'57.3"S, 043°54'48.4"W; 62 m a.s.l.; 11 Sep. 2018; S.R.S. Nascimento leg; light trap; LEAq. • 4 nymphs ♂; Maranhão state, Mirador municipality, Mirador state Park, Riacho Riachão; 06°41'19.8"S, 045°07'37.9"W; 320 m a.s.l.; 29 Jul. 2018. • 1 nymph ♂; same locality; Riacho Sítio; 06°44'27.6"S, 045°24'16.9"W; 361 m a.s.l.; 31 Jul. 2018. • 1 nymph ♂; same locality; Riacho Mel; 06°43'26.9"S, 044°58'36.4"W; 253 m a.s.l.; 28 Jul. 2018; S.R.S.Nascimento, L.R.C. Lima and D.A. Barbosa leg; aquatic net; LEAq. • 1 imago ♂; Maranhão state, Codó municipality, Rio Saco, BR316; 04°37'29.4"S, 043°54'09.1"W; 63 m a.s.l.; 22 Oct. 2019; S.R.S.Nascimento, L.R.C. Lima and J.I.S. Jesus leg; light trap; LEAq.

## Discussion

The order Ephemeroptera in the Brazilian Northeast Region is represented by 11 families, 48 genera, and 125 species. The family Leptophlebiidae has, so far, 41 species distributed in 19 genera (Salles and Boldrini 2020). The two states that had considerable knowledge of the family were Bahia, with 28 species and 14 genera (Campos et al. 2019; Campos and Mariano 2019; Costa et al.

2018), and Pernambuco, with 18 species and 13 genera (Lima et al. 2012a, 2012b; Lima et al. 2013, 2015). Here, we contribute to the data on the Leptophlebiidae in both the state of Maranhão and in the Northeastern Region.

We collected 815 specimens belonging to 15 genera and 20 species. Of these species, 18 are recorded for the first time from Maranhão state and six species are recorded for the first time from the Northeast Region: *Farrodes xingu*, *Hermanellopsis arsia*, *Hydromastodon sallesi*, *Miroculis (Atroari) duckensis*, *Thraulodes marreroi*, and *Tikuna bilineata*. Thus, the number of species in the Northeast Region has increased from 41 to 47 species. *Miroculitus emersoni* is the only species described for the genus. It was previously known only from Guyana (type location), based in a single male imago. This species' presence here represents the first record from Brazil and considerably extends its distribution in South America to the east.

We observed variations in the male genitalia of two species: *Hydrosmilodon gilliesae* and *Thraulodes marreroi*. Regarding the first, Salles et al. (2016) illustrated short (in lateral view) ventral spines converging medially on the penis lobes and apparently not reaching the basal half. In our specimens, we observed that these spines are long, about the same length as the penis. In *T. marreroi*, we did not observe that the penis had the apicolateral area forming a pronounced "ear", as observed by Chacón et al. (2009) in specimens from Venezuela and Kluge (2020) in specimens from Panama. We consider this difference as populational variation, because no other differences were found and because Gama-Neto et al. (2018) also observed some slight variations in this species.

With our data, the number of known leptophlebiids species in Maranhão has increased from three to 21. The high diversity of species and the number of new records demonstrate the importance studying the aquatic insect fauna of the Itapecuru, Parnaíba, and Tocantins river basins.

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**Figures 29–47.** Genitalia of some species of Leptophlebiidae (Ephemeroptera) found in Maranhão state, Brazil. **29.** *Askola emmerichi*. **30.** *Farrodes xingu*. **31.** *Hermanellopsis arsia*. **32.** *Hydromastodon sallesi*. **33.** *Hydrosmilodon gilliesae*. **34.** *Leentvaaria palpalis*. **35.** *Miroculitus emersoni*. **36.** *Miroculis (Atroari) duckensis*. **37.** *Paramaka convexa*. **38.** *Simothraulopsis demerara*. **39.** *S. diamantinensis*. **40.** *S. janae*. **41.** *S. sinuosus*. **42.** *Thraulodes luizgonzagai*. **43.** *T. marreroi*. **44.** *T. sternimaculatus*. **45.** *Tikuna bilineata*. **46.** *Traverella maranhensis*. **47.** *Ulmeritoides flavopedes*. Scale bars = 0.2 mm.

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### Authors' Contributions

SRSN and LRCL collected and identified the specimens; SRSN produced the photographs and map; SRSN, LRCL and CASA wrote the text.

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